Gas Hydrate Field **Experiments on the** Alaska North Slope: **Project Status**

Ray Boswell

Methane Hydrate Federal Advisory Committee Meeting: Galveston, TX

February X, 2020











Status of GH Science (wrt Production Tech.)



Extended Duration Field Tests are the Global #1 Priority in GH R&D



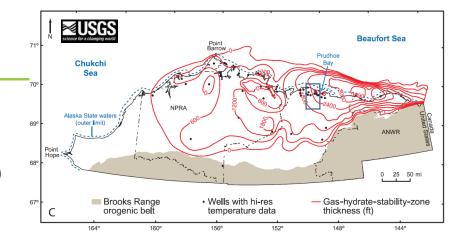
- Active government-led R&D underway in the US and by key US allies for whom future energy security is a priority for US and global energy security. (Japan, India, S. Korea).
- These nations have invested \$1billion+ in field programs but have to date been unable to observe hydrate production response for sufficient duration.
 - Onshore (Canada) → lack of infrastructure
 - Offshore (Japan) → high costs and operational complexity
- A two-year effort by US, Japan, and State of Alaska indicated high costs and risks of test outside the PBU infrastructure area.
- ANS greater PBU region provides the only known location to enable viable long-term scientific testing.

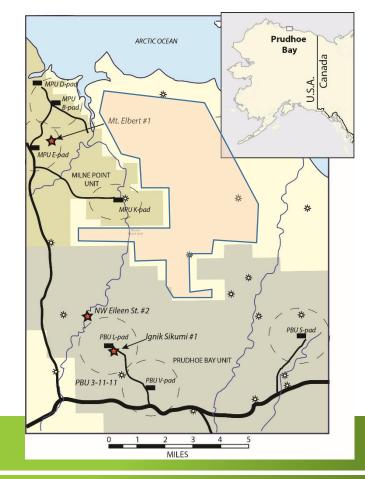


Quick History

GH Evaluation in Alaska and N. Canada

- GH system known in Arctic since the 70s (industry tests NW E-St-2. USGS. Mallik beginning '98)
- 2004: "Hot Ice" Project (failed G&G effort)
- 2007: MPU Mt Elbert Project (off ice: G&G and operational success)
- 2006-07: Japan-Canada Mallik Test (successful depressurization demonstration)
- 2010: PBU L-pad long-term depressurization & injection test (legal/logistical barriers)
- 2011-12: PBU "Iġnik Sikumi" test
 (on ice test focused on gas injection and well operations)
- 2013: Unit interest waned
- 2014- 2015: US-Japan AK State Lands Review (w/ DNR)
 (unacceptable geologic and operational risks)







Project Structure



Statement of Intent (6/2008)





Memorandum of Understanding (4/2013)





Memorandum of Understanding (11/2014) CRADA (12/2018)



































CONTRACTUAL

PHASE 1 (Completed): Stratigraphic Test Well





Contract to PRA





Drilling Services Agreement with BPXA



PHASE 2 (Planned): Production Test Wells

(w/2nd Monitoring well and surface facilities)







Clarification of the nature of 3rd Party Operations in the Unit and handling of project legacy issues







Drilling Services for 2nd Monitoring Well Select other services (i.e. water handling/disposal





Contract to Operator



Services for Surface Facilities construction/operations Drilling/Testing Services for Production Test Wells



Project Structure



Jointly funded and managed



MOU (general) **CRADA** (project specific)



Steering Committee

Brian Anderson (Director of NETL)

Timothy Reinhardt (Director of Supply and Delivery, Office of Fossil Energy, DOE)

Toshikazu Ebato (Executive Vice President)

Koji Yamamoto (Group Leader of Methane Hydrate R&D Group)

Authorize implementation plan at each stage gate.

Administration Coordinator

Contract formulation and execution and budget expenditure.

Nori Okinaka (JOGMEC) Don Hafer (NETL)

R&D Committee

Science/technology implementation plan.

Nori Okinaka (JOGMEC)

Ray Boswell (NETL)

Tim Collett (USGS)

Many other per Topic

Site Representatives

Real-time decision-making during field programs.

Ray Boswell (NETL), Tim Collett (USGS), Scott Marsteller (NETL) Nori Okinaka, Motoi Wakatsuki (JOGMEC)

Decision Making Mechanism



Program Objectives



Robust, Proven, State-of-art Equipment for Well Sampling, Completion, and Monitoring

Science

Full characterization of GH systems → Physical Properties, Geomechanics, Petrophysics

- Sidewall pressure coring (STW)
- Whole core pressure coring (GDW)
- Full suite LWD and wireline logs (all wells)

Observation of controlled perturbation → Dynamic Geomechanics, Petrophysics, Heat Flow

- Fiber-optic Strain, Acoustic, and Temperature Monitoring
- Pressure monitoring (cables and/or gauges)
- Monitoring inside (PTW) and outside (PTW, STW, GDW) casing

Time SeriesVSP via DAS → Reservoir System Response

Technology

Assessment of Mitigations to emergent production challenges (heat flow, permeability, geomechanics)

- Sand control/completion/stimulation/shut-in
- Artificial Lift; Hydraulic isolation

Improved evaluation/prediction of productivity and potential

• Numerical simulation (needed validation/calibration datasets)





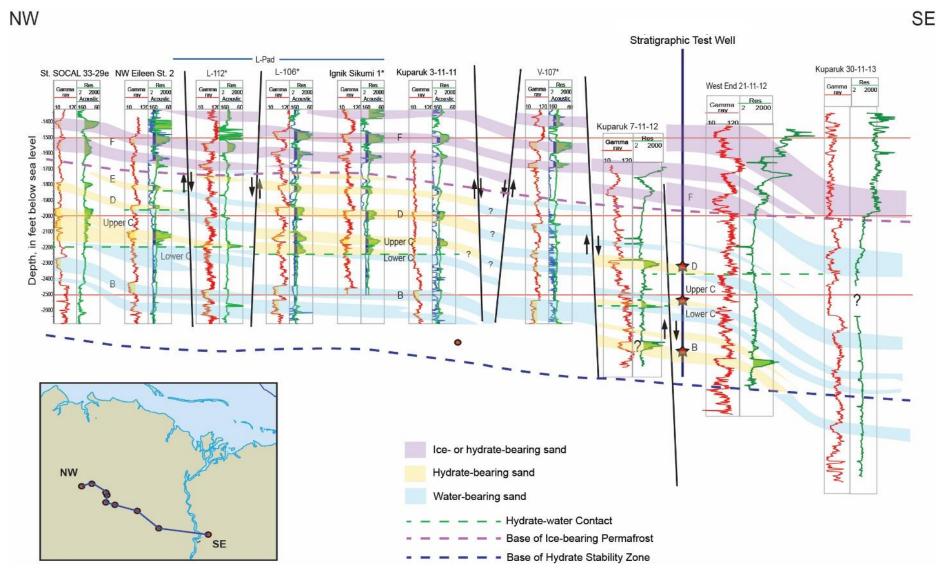


Examples of tools under consideration



Review of Sites: Westend PBU

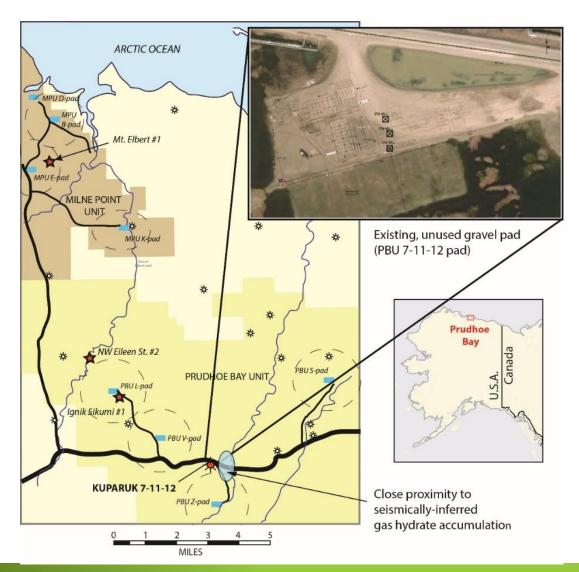






2016: Return to the Prudhoe Bay Unit





- Working Interest Owners agreed to consider a test that could be conducted with no interference to ongoing operations
- AK DNR/PBU provide regional seismic data
- Promising location identified accessible from an unused gravel pad along a year-round road.
- Existing well and seismic data evaluated to assess geologic risk

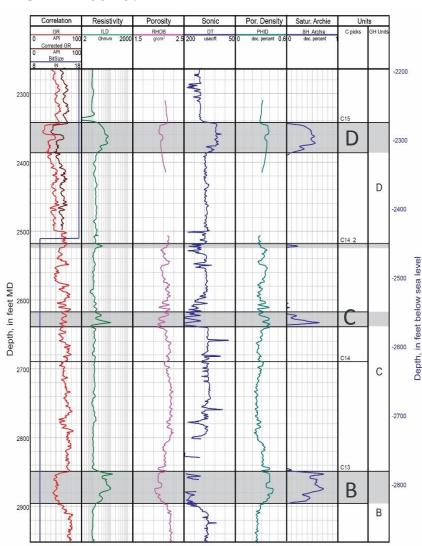


Kuparuk 7-11-12 Well Site (PBU)



Confirmed GH in D sand. Limited GH in C sand. Uncertain GH in B sand.

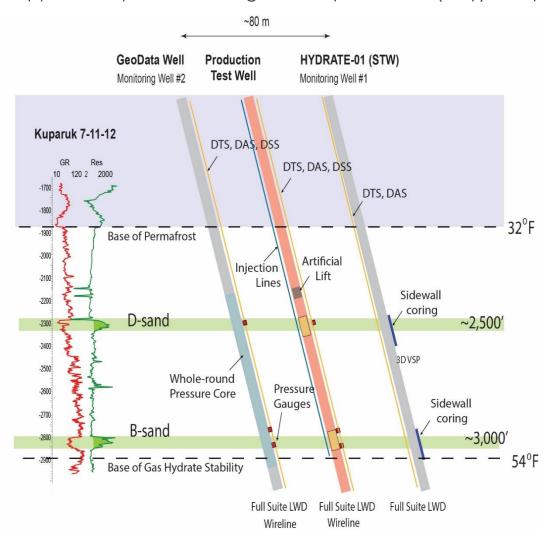
- Two older exploration wells from pad
- D-sand: GH likely (low geologic risk)
- C-sand: limited charge.
- B-sand: HC-charge but poor log quality.
- Drilling-disturbed at time of logging
- B-sand predicted to occur within 100' of BGHS
- Slight well deviation: BHL away from old boreholes
- Assess potential for nearby free-gas or water
- Map faults

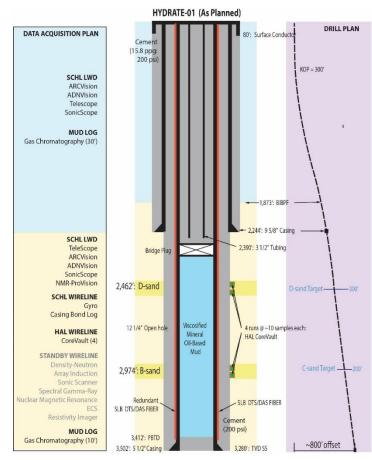


Proposed 7-11-12 Field Program



Approved by PBU: BPXA agrees to operate STW (only) as a part of Unit Business.



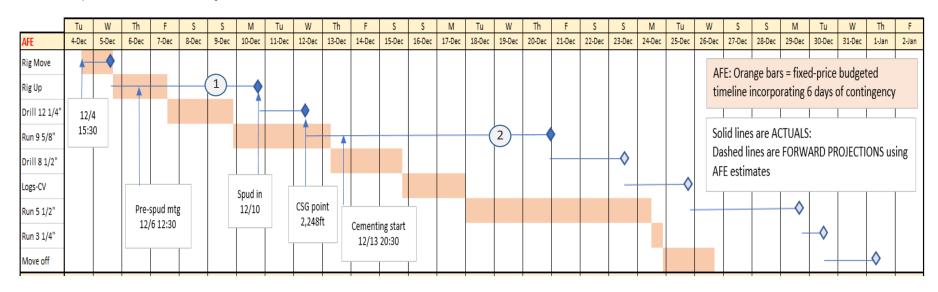




December 2018 STW Operations



Safe Operations; no injuries or HSE events.



AFE = planned 22-day operational timeline including BAU contingencies = basis for the Fixed-Price estimate.

ACTUAL includes several minor incidences and two primary events of lost time

- (1) An initial 3 day delay prior to well spud that was the result of PBU Operations.
- (2) A second 5-day delay occurred during running surface casing and setting up mud temp controls to drill out.

Ultimately ~25 days of operations (3 days over fixed-price plan).



Data Acquisition – Results Detail



Drilling/wellbore quality (to allow reliable data collection)

- FULLY ACHIEVED: both targets penetrated within provided target*. Mud temperature maintained within set limits (as modified). No incidents of induced GH dissociation; hole in gauge.
- **NOTE**: Log data indicate 14' fault present in close proximity to wellbore.

Logging-while-drilling (data to confirm/characterize reservoir condition)

- FULLY ACHIEVED: outstanding quality data with all tools!
- **NOTE**: Sonic data muted reservoir response in lower portion of B target. Verified proper tool response through two additional MAD passes across the reservoir.

Contingency Wireline data

DEFERRED PER PLAN: not required due to high quality of LWD data

Sidewall pressure cores (to allow grain size analyses & test well completion design)

- FULLY ACHIEVED: 34 samples recovered spanning full extent of both reservoirs.
- **NOTE**: Attempts (in US and in Japan) to gather additional petrophysical data from the best samples ongoing.

Fiber Optic cable installation (to enable use of STW as monitoring well)

• FULLY ACHIEVED: two (one as backup) distributed temperature/acoustic sensor cable packages were installed on outside of casing and successfully tested.



Bottom-hole assembly for main hole (from Schlumberger)



Easily Correlated Short Step-out



Unit D

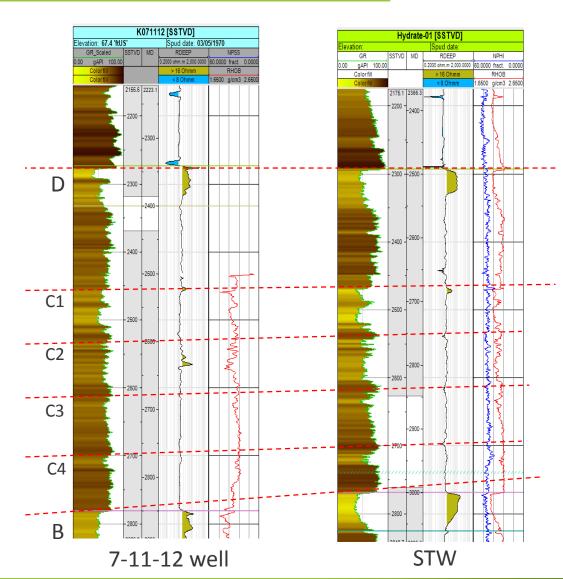
• In better condition (no internal shale break; cleaner top)

Unit C

• Virtually identical.

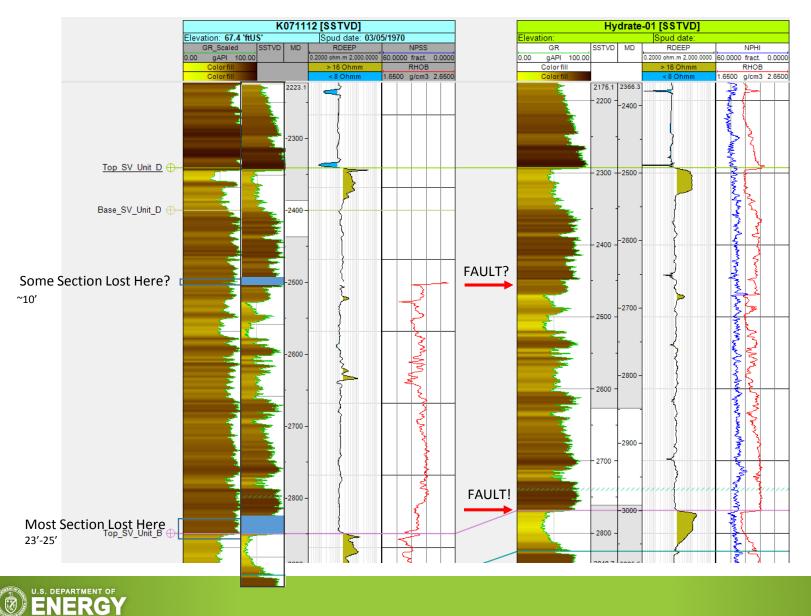
Unit B

In better condition (lower GR);
 more uniform RES and DEN);
 clear GH indicators (SON)



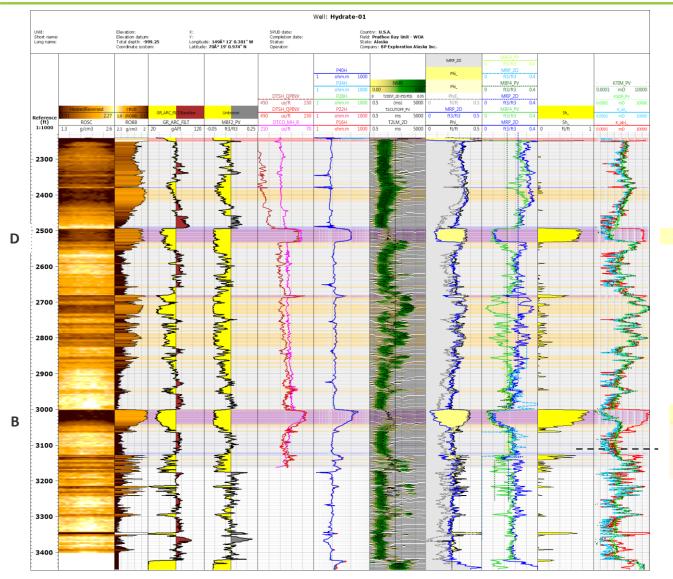
Inferred Faulting in the Hydrate-01 well

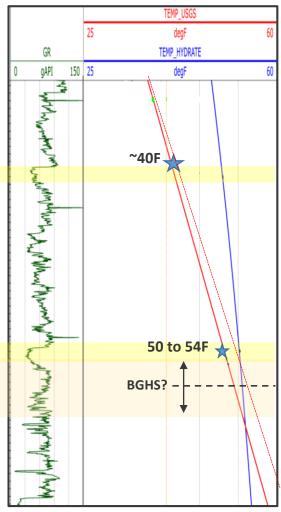




Summary STW Log Data



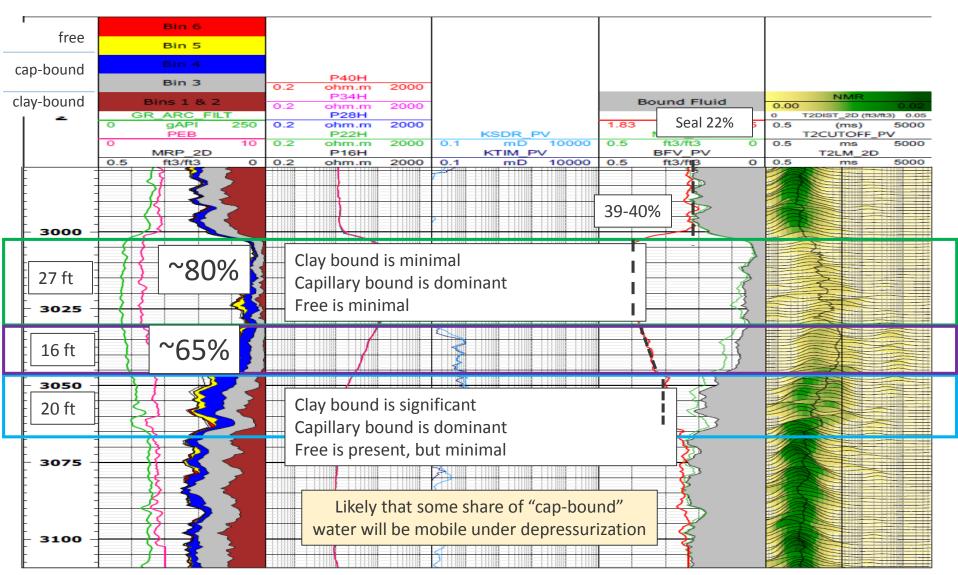






Log Data: Unit B

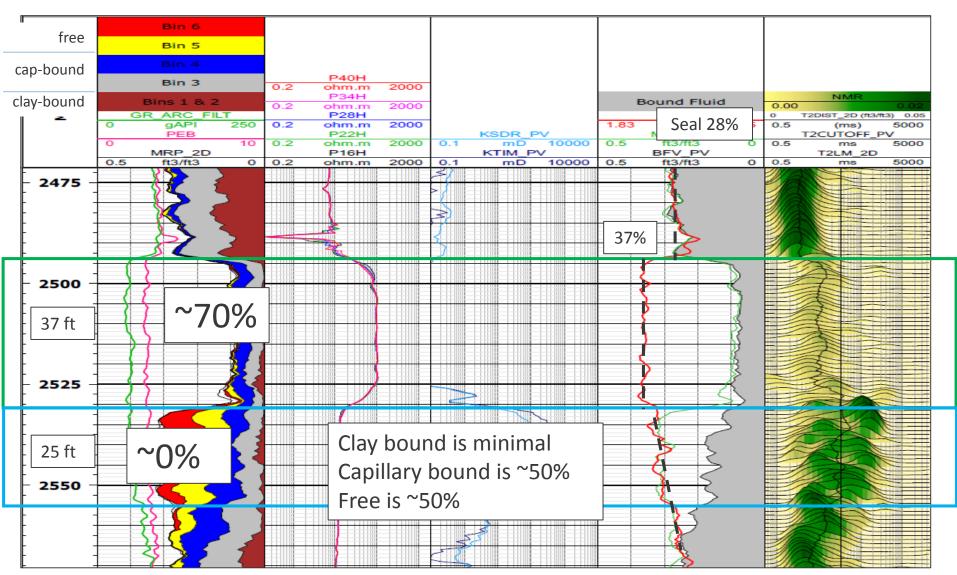






Log Data: Unit D







Ongoing Site Monitoring

NATIONAL ENERGY TECHNOLOGY LABORATORY

Funded by JOGMEC

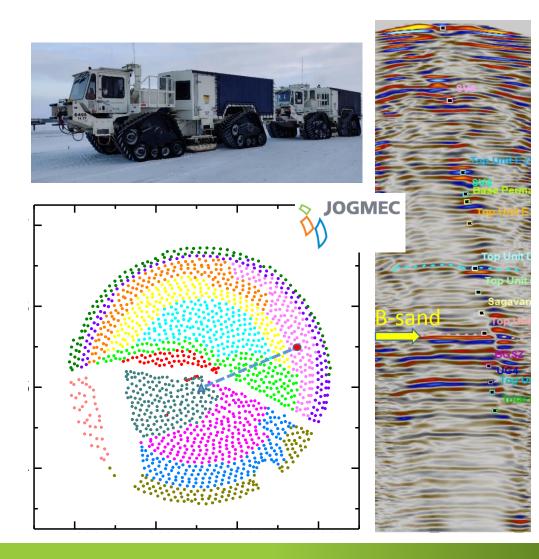
DAS-VSP utilizing FO DAS cables

- Among largest known DAS-VSP acquisitions to date
- Local structural/stratigraphic heterogeneity
- Regional well to seismic tie
- Phase distribution
- Additional 3D-VSPs planned (before, during and after testing).

Sub-seismic fault imaged

- Interpreted from log data
- Not visible on surface 3-D seismic

Baseline surveys for elevation (subsidence)

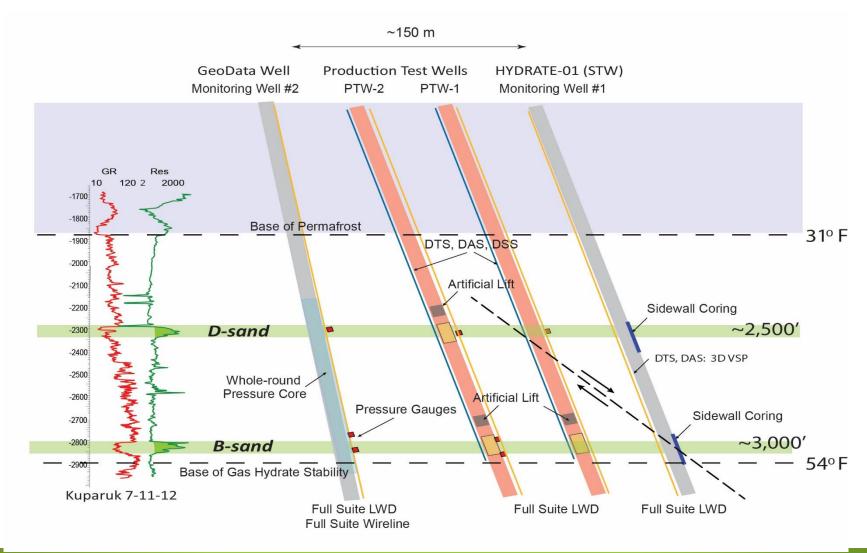




Current Testing Plan



Addition to the plan of a second PTW to mitigate risk/expand test flexibility





GDW and PTW-1, PTW-2 Data Acquisition





- **GDW LWD:** TeleScope; arcVISION; adnVISION; SonicScope; PowerDrive.
- **GDW WLL:** Not contingent. PEX; RtScanner; SonicScanner; CMR/MRScanner; HNGS; QuantaGeo; ECS
- GDW: Left in accessible state for production logging: Gyro; IsolationScanner; RST
- PTWs Surface LWD: Simplify (PowerDrive; MWD; GR) to maximize hole quality (assuming data success in GDW)
- PTWs Main LWD: As GDW, with WLL (as GDW) contingent on data quality
- Utilize HPTC in GDW. Stage PCATS labs on location. No planned conventional coring
- **GDW-PTW Mud-logging** as STW with addition of isotubes.

	STW	GDW	PTW1	PTW2
DTS	V	V	V	V
DAS	~	✓	✓	✓
TAS		✓		
P behind CSG		v	✓	~
P tubing			v	✓
DSS		v	v	v

Modeling: Setting Input Model

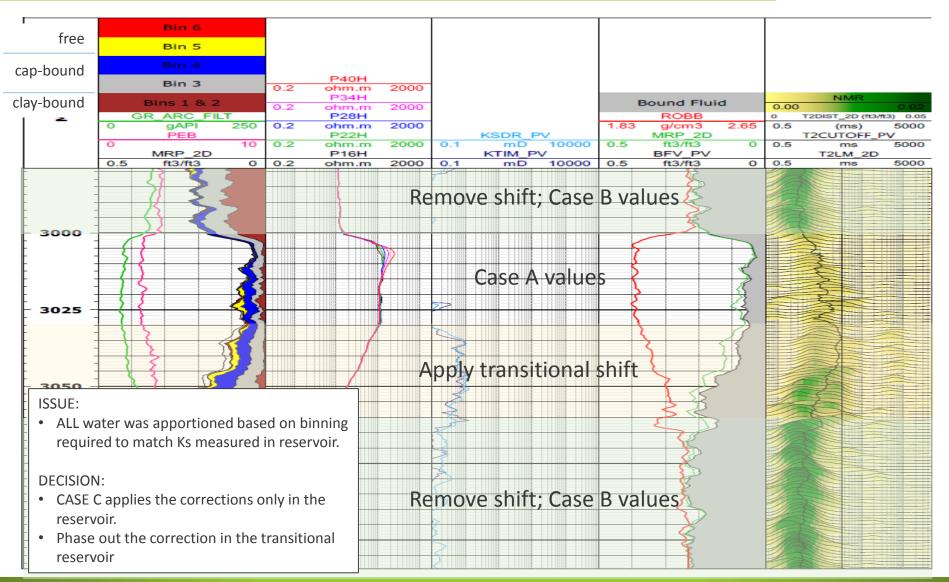


		c	ASE A & B:	WATER DI	STRIBUTIO	N	CASE A	(core)	CASE B ((NMR log)		CASE C WATER DISTRIBUTION CA						CASE C (Water)			
Porosity model	Sh	Volume ratio (Total volume=1)						Kintrinsic	Keff	Kintrinsic		Volume ratio (Total volume=1)					Keff	Kintrinsic			
PhiT	Hydrate saturation within PhiT	CBW Volume	BFW volume	FFW Volume	Hydrate volume	Matrix volume	Add cutoff: Ki min (=0.001) set	Add cutoff: Ka min constrain		Lower of TC		CB ¹ Volu		FFW Volume	Hydrate volume	Matrix volume	Add cutoff: Ki min (=0.001) set	Add cutoff: Ka min constrain			
(2.69- Rho_c) /(2.69-1)	DMR method in reservoirs. Set to Zero elsewhere	<3ms	3ms-10ms	>10ms + "False hydrate"	PhiT*Sh	1- (CBW+BF W+FFW+V mh)	= Kintrinsic where Sh=0 <u>Final Ki</u>	(=0.001) Final Ka		and KC methods		<3m share hydr	alse + share	>10ms + "False hydrate"	PhiT*Sh	1- (CBW+BF W+FFW+V mh)	= Kintrinsic where Sh=0 <u>Final Ki</u>	(=0.001) Final Ka			
ft3/ft3	ft3/ft3	ft3/ft3	ft3/ft3	ft3/ft3	ft3/ft3	ft3/ft3	mD	mD	mD	mD		ft3/f	ft3/ft3 ft3/ft3 ft3/ft3 ft3/ft3		mD	mD					
0.248	0.000	0.120	0.075	0.052	0.000	0.752	11.502														
0.250	0.000	0.111	0.074	0.065	0.000	0.750	17.111		2.414												
0.240	0.000	0.105	0.076	0.059	0.000	0.760	18.039														
0.237 0.235	0.000 0.000	0.106 0.097	0.074 0.073	0.057 0.065	0.000 0.000	0.763 0.765	16.766 22.158	16.766 22.158	1.557 2.218												
0.244	0.000	0.097	0.073	0.003	0.000	0.756	29.720	29.720	4.527												
0.259	0.000	0.080	0.072	0.108	0.000	0.741	53.061	53.061	11.462			We have three modeling cases to constrain gas and water rates									
0.271	0.000	0.082	0.065	0.123	0.000	0.729	57.807	57.807	18.538	18.538											
0.305	0.000	0.080	0.066	0.159	0.000	0.695	97.198	97.198	51.186	51.186											
0.333	0.538	0.066	0.061	0.027	0.179	0.667	26.415		0.244	159.384			COMSURA	iii gas	anu w	aterra	ates				
0.367	0.648	0.049	0.059	0.021	0.238	0.633	29.495		1				. Canaa		(C/	(CE D) 6					
0.391	0.740	0.030	0.053	0.019	0.289	0.609	27.706		0.054				 Conser 	valive c	ase (CA	(2E B) D	iased of	1			
0.407 0.422	0.805 0.860	0.020 0.009	0.043 0.036	0.017 0.014	0.328 0.363	0.593 0.578	20.741 14.050	1315.149 1900.280	0.029 0.012			NMR- Ks									
0.422	0.889	0.009	0.030	0.014	0.303	0.570	9,903	2247.402	0.012												
0.430	0.899	0.005	0.031	0.012	0.302	0.578	8.906	2544.184	0.000				 Aggres 	sive cas	e (CASI	E A) bas	sed on				
0.442	0.905	0.005	0.029	0.008	0.400	0.558	7.742	2528.012	0.001	2715.411				orrectio							
0.435	0.905	0.007	0.026	0.008	0.393	0.565	7.114	2264.573	0.002	2491.406					II OI IVI	יווי נט נו	ic entil				
0.424	0.906	0.007	0.024	0.009	0.384	0.576	6.479	2024.362	0.002	2220.717			section	١.							
0.423	0.909	0.010	0.020	0.008	0.384	0.577	5.523		0.002							> -					
0.431	0.920	0.009	0.017	0.008	0.396	0.569	4.634	2078.145	0.001	2359.881			 Most L 	ikely cas	se (CAS	E C) ba	sed on				
0.432	0.906	0.011	0.015	0.015	0.392	0.568	6.319		0.009				core-co	orrectio	n only i	n the m	nain				
0.432 0.435	0.919 0.929	0.003 0.002	0.020 0.021	0.012 0.008	0.397 0.405	0.568 0.565	5.373	2368.485	0.004												
0.435	0.929	0.002	0.021	0.008	0.405	0.565	4.253 8.702	2508.381 2454.864	0.001 0.012	2566.160 2581.186			reservoir units AND removal of log resolution "boundary" effects								
0.437	0.891	0.004	0.025	0.018	0.388	0.565	10.347	2496,709	0.012												
0.430	0.888	0.002	0.027	0.013	0.382	0.570	10.558	2355.308	0.020			Tesolation boundary effects									
0.430	0.872	0.005	0.032	0.018	0.375	0.570	13.270		0.020												



Most Likely Case



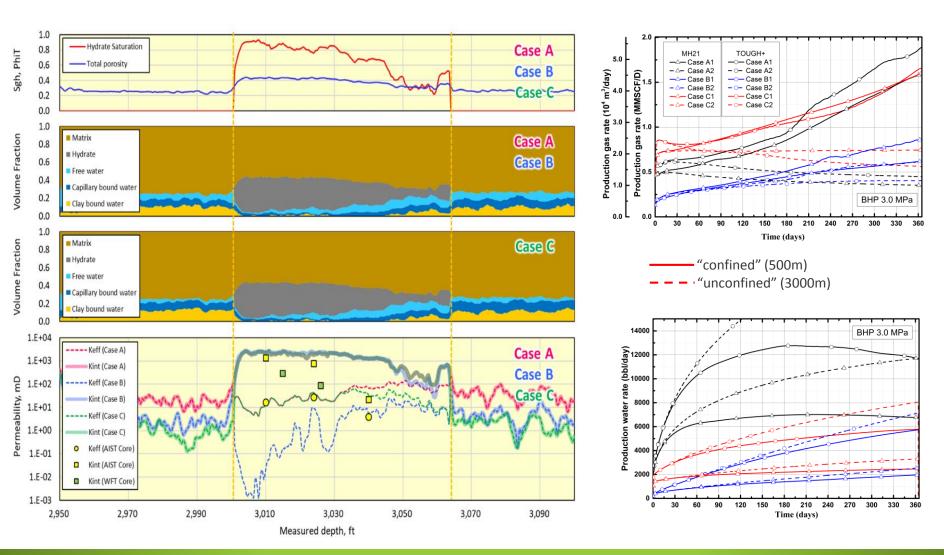




Modeling: NETL/JOGMEC



Code Comparision – Constraint on max gas and water rates to guide surface facility design



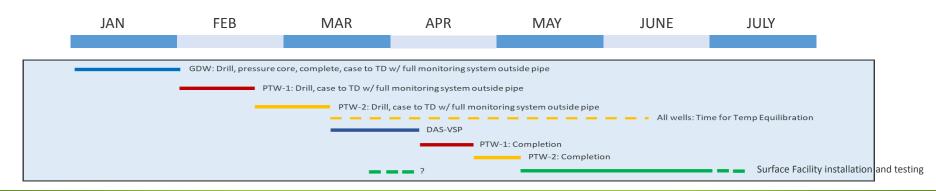
Key Components of Testing Plan



As distinct from PTW completion design

Base Production Method: Depressurization

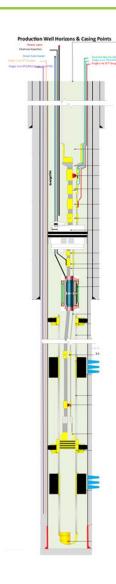
- Maximize data interpretability by imparting a single driving force
- Employ a step-wise pressure reduction to max. scientific insight and to minimize operational risks associated with large drawdowns
- First step at P > GHS to assess water mobility.
- Add'l steps set at ~2.0 mPa (to be refined via focused engineering studies)
- Follow well intervention/stimulation protocols where reservoir response dictates
- At end of test, impart largest feasible pressure drop





Technical Plans: Testing Phase





- <u>Highest priority</u>: safety; reg. compliance; no disturbance to PBU Ops
- Focus: monitoring reservoir response
 - Periodic VSPs to assess system response (geometry/scale)
 - DTS/DSS and P-gauges in 4 wells to monitor dissociation reaction and impacts in 4D
- Focus: well design & survivability
 - Artificial lift: robust, viable across expected flow range
 - Flow assurance; pre-staged intervention: downhole heater
 - Sand control/Hydraulic isolation cased/perfed with screens; GeoFORM
 - Staged shut-in and restart procedures (nitrogen)
- Focus: water, gas, and solids handling
 - Water/Sand: local storage w/ sufficient excess. Trucking and disposal in unit facilities
 - Gas: local consumption.
- NOTE: all plans developed to-date by JOGMEC, USGS, DOE will be worked with TPO and PBU WIOs once testing program is authorized to proceed and TPO selected

Intervention Plan



Ongoing

Flow Assurance: Shut-in & remediate

Gas Rate (low, declining, erratic, persistently flat)

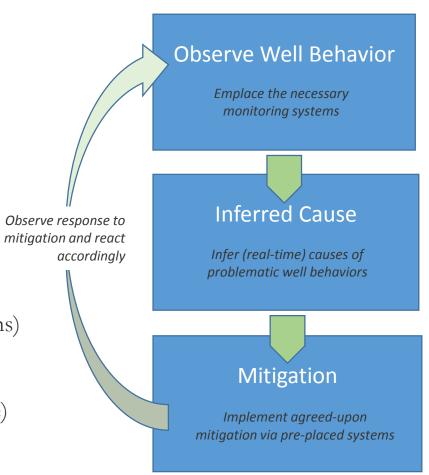
- Hydrate formation → P drop and monitor
- Ice formation → P drop and monitor: hot methanol
- Sand/fines blockage → P cycling: acid?: re-perf
- Gas-Water block → P cycling
- Reservoir Limitation → stimulation... TBD
- Equipment failure → shut in and repair

Excessive Sand (robust systems; cleanout options)

• Systems failure → patience, move to D

Excessive Water (ensure adequate onsite storage)

• Reservoir → P drop; P cycling, move to D



Next Project Phase: Status



As of February, 2020



- Initial Stratigraphic Test has confirmed site geologic feasibility
- Steering Committee approved effort to advance to next project phases.
- Limited business case for industry participation; however, PBU has desired to facilitate a "standalone" test.
- An atypical DOE/FE project context: directed to pursue science and technology w/o interested private R&D partners to assume risks and share costs
- Sustaining interest from our partners in Japan and from the State of Alaska.
- Impending exit of BPXA and entrance of Hilcorp, Alaska has challenged efforts to maintain schedule. Currently holding to plan for drilling as early as next winter season



THANK YOU

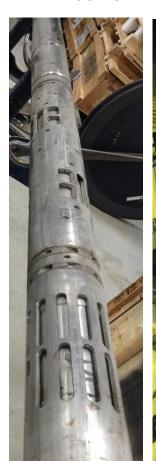


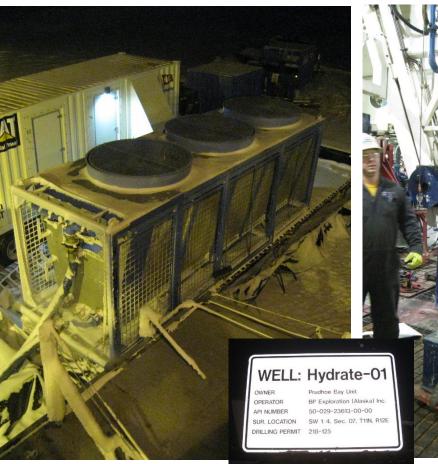
LWD Sonic

Passive Mud Chiller

CoreVault

Fiber Optic Cables



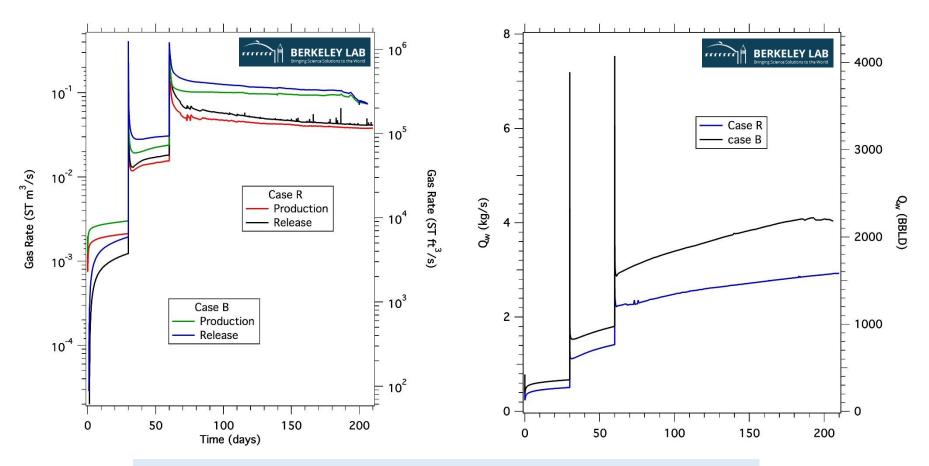




Modeling: LBNL



Focused analyses of reservoir response to inform completion design and test design.



Focused study needed with regard to A) confirming optimal pressure drawdown increments B) confirming optimal completion interval with respect to water C) refining optimal well stimulation contingency options (specific means; potential effectiveness; and logistics of pre-positioning)



Sidewall Core Analysis

B zone



Measured at AIST, Sapporo Japan



B zone

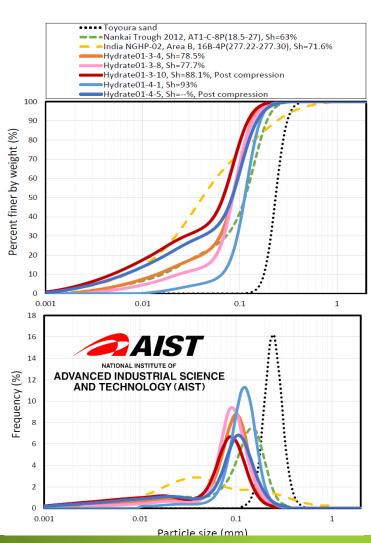
Additional measurements taken at Weatherford Labs, Denver, Colorado

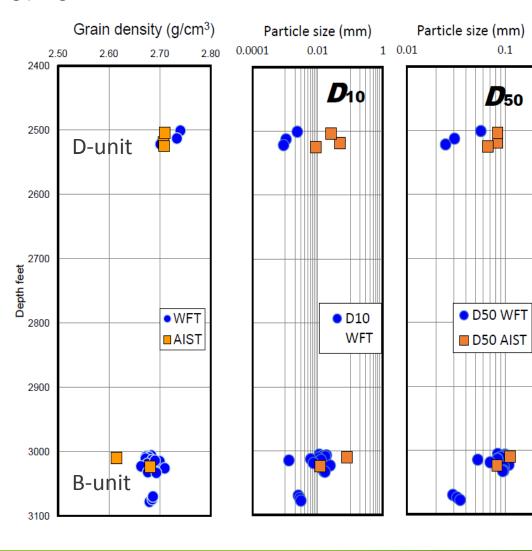


Grain Size and Density



Primary science objectives of sidewall coring program

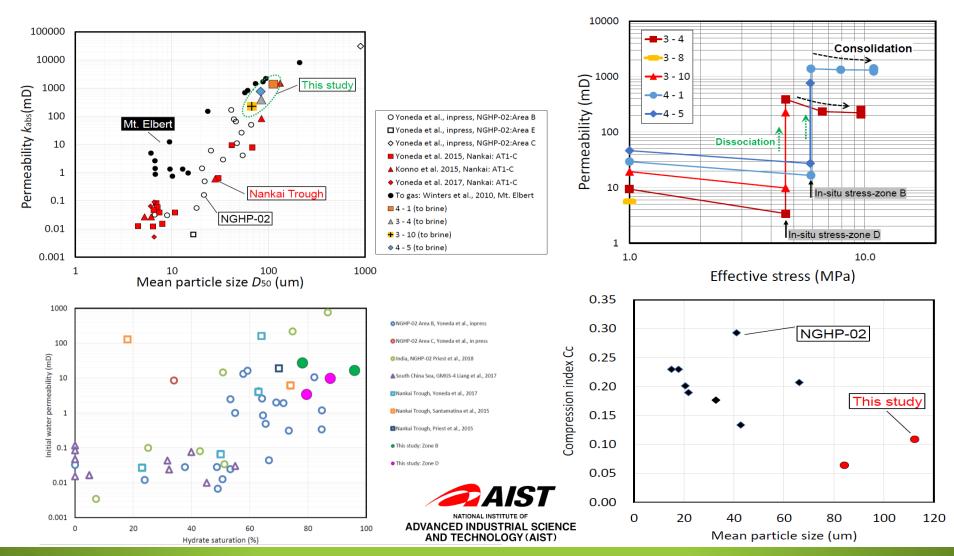




Petrophysics & Geomechanics



Surprising Success with Analyses of Preserved Sidewall Pressure Cores



India Update



India NGHP-02: Published 800+ page volume summarizing NGHP-02 science outcomes

- Geologic Systems (reservoirs, water, seals)
- Pressure Core Evaluation (permeability, compressibility)
- Numerical Simulation (gridding, geomechanics)

India NGHP-03: Planning for next phase of program

- Recommendation for two-phases to include initial prospect delineation drilling and second phase testing
- Potential joint NGHP-03 site review (G&G) activity with USGS, BOEM

Marine and Petroleum Geology 108 (2019) 39-142



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journal homepage: www.elsevier.com/locate/marpetgeo



Research paper

India National Gas Hydrate Program Expedition 02 Summary of Scientific Results: Gas hydrate systems along the eastern continental margin of India



Timothy S. Collett^{a,*}, Ray Boswell^b, William F. Waite^c, Pushpendra Kumar^d, Sandip Kumar Roy^e, Krishan Chopra^e, Sunil Kumar Singh^e, Yasuhiro Yamada^f, Norio Tenma⁸, John Pohlman^c, Margarita Zyrianova^a, and the NGHP Expedition 02 Scientific Party

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- Japan Agency for Marine-Earth Science and Technology, Kanagawa, Yokosuka, 237-0061, Japan
- 8 National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, 305-8560, Japan

ARTICLE

Keywords: Gas hydrate



Natural Gas Hydrates: Status of Potential as an Energy Resource

Ray Boswell¹, Steve Hancock², Koji Yamamoto³, Timothy Collett⁴, Mahendra Pratap⁵, Sung-Rock Lee⁶

¹NATIONAL ENERGY TECHNOLOGY LABORATORY, PITTSBURGH, PA, UNITED STATES; ²XTREMEWELL ENGINEERING INC., CALGARY, CANADA; ³JAPAN OIL, GAS, AND METALS NATIONAL CORPORATION, TOKYO, JAPAN; ⁴UNITED STATES GEOLOGICAL SURVEY, DENVER, CO, UNITED STATES; ⁵DIRECTORATE GENERAL OF HYDROCARBONS, DELHI, INDIA; ⁶KIGAM, SEOUL, SOUTH KOREA









Hydrate-01 Well House

Wellhead of Hydrate-01



Summary



Ongoing effort to conduct Long-term Gas Hydrate Production Test



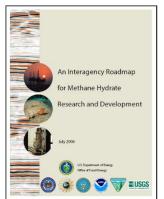
- Alaska North Slope is a "natural laboratory" to assess GH production technology
 - long-term testing remains the #1 priority in global gas hydrate science.
 - the only feasible spot world-wide to attempt long-term testing (GH onshore with infrastructure).
- A collaborative effort to develop a Project is ongoing
 - parties are DOE, JOGMEC, USGS, and State of Alaska
- Key Challenges
 - logistics/contracting for a 3rd party to operate standalone production test on our behalf.
 - Must meet the requirements for alignment with PBU WIOs and AK state agencies
 - proper well design to maximize well survivability to obtain project objectives

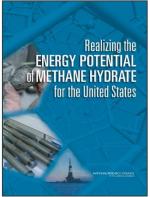


Alaska Testing: A Long-standing Priority



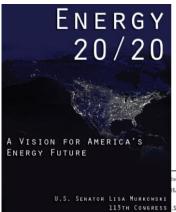
Internal, Interagency, External Oversight, Congressional, Programmatic













lucing More Unconventional Fossil Fuels

hane Hydrates and Other Unconventional Gas Resources

133TH CONGRESS . S. contains an estimated 200,000 trillion cubic feet (TCF) of methane hydrates – methane natural gas locked in solid, ice-like structures, underground or under the sea floor. **According to the USGS, Alaska alone contains between 560 and 600 trillion cubic feet of methane hydrate onshore* and approximately 160,000 TCF offshore. **B once safely unlocked, Alaska's methane hydrate resources could power America for nearly 1,000 years at current rates of gas consumption, according to the Alaska Division of Geological and Geophysical Surveys (ADGGS). **Important steps we need to take to access these resources include:

Expedite research on methane hydrate well flows to prove that methane will continue to "flow" to
the surface after drilling efforts. Increase funding for environmental reviews of the effects of liberating methane hydrates, the resulting land impacts, and for research already underway by the DOE
National Energy Technology Laboratory (NETL).

Memorandum of Understanding Alaska Department of Natural Resources

U.S. Department of Energy, Office of Fossil Energy Energy Research, Methane Hydrates, and Other Unconventional Resources in Alaska

A Memorandum of Understanding (MOU) between the Alaska Department of Natural Resources (Alaska DNR) and the United States Department of Energy, Office of Fossil Energy, (DOE/FE) regarding energy development and unconventional resource research and demonstration in Alaska's Arctic.

Whereas, Alaska DNR's mission is to responsibly develop Alaska's resources by making them available for maximum use and benefit consistent with the public interest.

Whereas, DOE/FE is responsible for managing the Department of Energy's fossil energy research and development programs and advising the Secretary of Energy on all matters related to our nation's fossil energy resources, including research and demonstration of methane hydrates, viscous oil, and other potential unconventional resources.

Christopher A. Smith
Assistant Secretary
Office of Fossil Energy

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Chapter 7: Advancing Systems and Technologies to Produce Cleaner Fuels

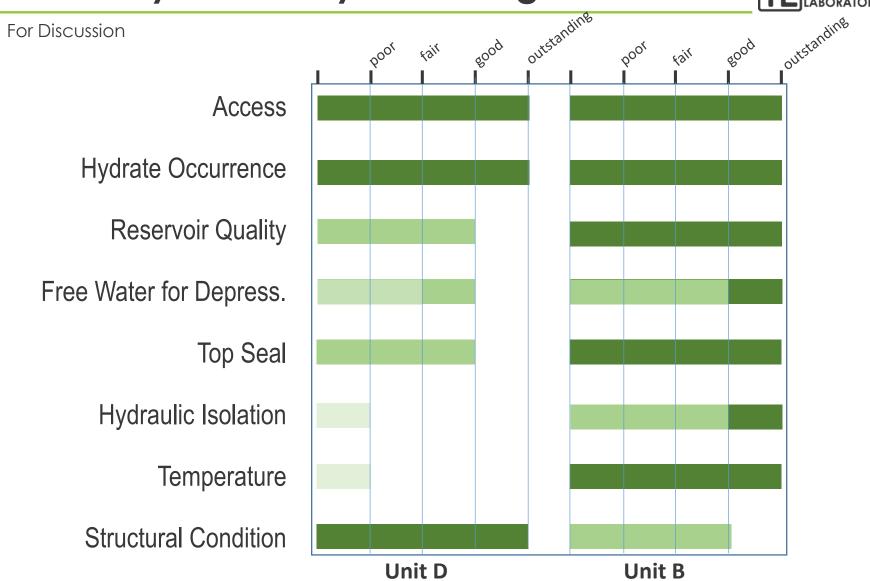
Technology Assessments

ENERGY



Summary: Suitability for Testing





Review of Relevant Prior GH Field Tests

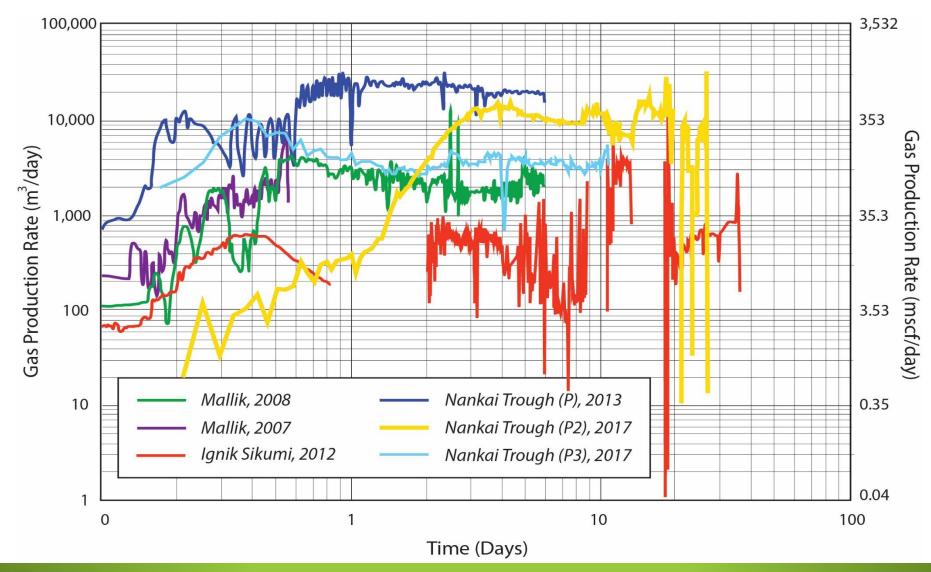


Production Test	Mallik 2002	Mallik 2007/2008	lġnik Sikumi 2012	Nankai 2013	Nankai 2017	
Site Location	McKenzie Delta, Canada	McKenzie Delta, Canada	North Slope, Alaska, U.S.A.	Nankai Trough, Japan	Nankai Trough, Japan	
Year	2002	2007/2008	2012	2013	2017	
Partners	Consortium of Japan, Canada, DOE&USGS, Germany, India	JOGMEC (MH21 NETL, ConocoPhillips, JOGMEC (MH21 , NRCan Research Consortium)		JOGMEC (MH21 Research Consortium)	JOGMEC (MH21 Research Consortium)	
Production Method	Hot fluid circulation	Depressurization CO ₂ injection / Depressurization		Depressurization	Depressurization	
Cumulative Gas Volume (Standard cubic meters)	470: (5 days)	2007: 830: (12.5 hours) 2008: 13,000: (6 days)	24,000: (30 days)	119,000: (6 days)	P2: 40,850: (12 days) P3: 222,600: (24 days)	
Results	First gas production form MH reservoir by hot fluid circulation method. Confirmed effectiveness of depressurization method by short term depressurization test.	First gas production from MH reservoir by depressurization method.	Confirmed replacement methane gas with CO ₂ .	First offshore production test.	Longer flow-term than Nankai 2013.	
Challenges	Challenges Longer term production. Energy efficiency.		Efficiency of replacement	Mitigation of production issues.	Long term production behavior. Increase production rate.	



Prior GH Field tests

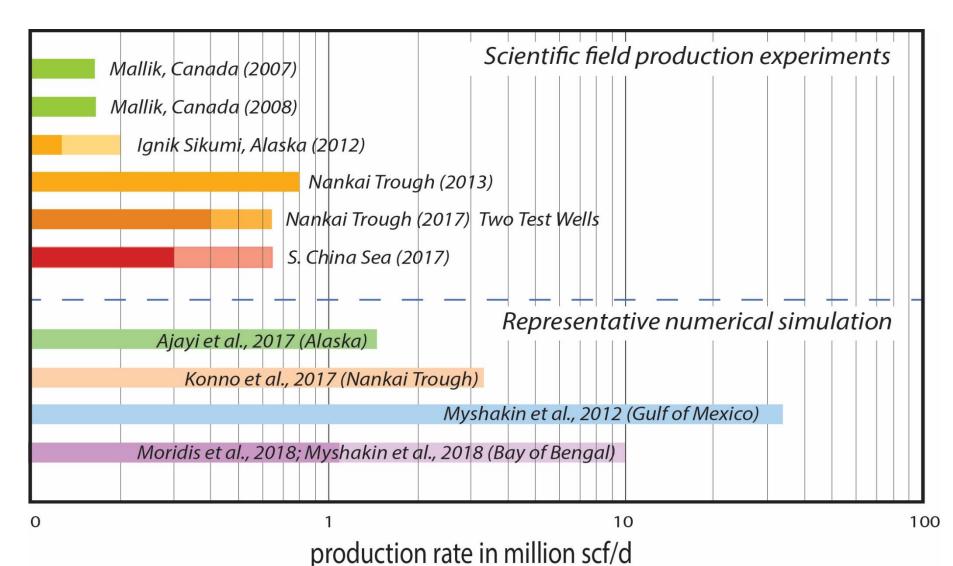






GH field and simulation estimates







Baseline Elevation Modeling



Ongoing

PRIMARY & SECONDARY MONUMENTS																
NORTHING	EASTING	ELEVATION (NAVD88 FEET)														Δ
NAD27, AS	Oct. 20, 2018	Δ	Nov. 18, 2018	Δ	May 15, 2019	Δ	June 17, 2019	Δ	Nov. 21, 2019	Δ	Dec. 18, 2019	Δ	Jan. 15, 2020	OCT. 2018 TO Jan 2020	AVERAGE OF Δ FROM INITIAL TO CURRENT SURVEY	
5,964,602.907	602,087.608	45.11	0.10	45.21	0.01	45.22	-0.03	45.19	0.23	45.41	-0.02	45.39	0.01	45.40	0.29	0.05
5,965,836.854	595,751.934	51.72	-0.01	51.71	-0.01	51.70	-0.01	51.69	0.19	51.88	0.00	51.88	-0.01	51.87	0.15	0.02
5,967,797.833	596,105.524	49.62	0.01	49.63		-	-0.02	49.61	0.08	49.69	0.06	49.75	-0.03	49.71	0.09	0.02
5,967,859.245	601,693.879	41.91	0.02	41.93		-	-0.01	41.92	0.15	42.07	-0.01	42.06	0.00	42.06	0.16	0.03
5,967,939.896	598,945.498	45.43	-0.01	45.42		-	-0.03	45.39	0.01	45.40	0.05	45.44	-0.03	45.41	-0.02	0.00
5,967,391.326	598,299.204	46.56	0.06	46.62		-	-0.03	46.60	0.16	46.76	0.01	46.77	-0.01	46.75	0.19	0.04
5,967,424.008	600,217.484	43.82	-0.01	43.81		-	-0.01	43.79	0.10	43.89	-0.01	43.88	0.02	43.90	0.08	0.02
5,967,138.112	599,277.809	43.78	-0.01	43.77		-	-0.05	43.72	0.06	43.78	0.01	43.79	0.03	43.82	0.04	0.01
5,966,641.809	598,502.961	47.55	0.03	47.58		-	-0.05	47.53	0.07	47.60	0.03	47.63	0.01	47.65	0.10	0.02
5,966,382.782	599,809.095	46.06	0.02	46.08		-	0.01	46.08	0.15	46.23	0.01	46.24	-0.01	46.23	0.17	0.03
5,966,176.036	600,626.421	45.95	0.02	45.98		-	-0.02	45.95	0.11	46.06	0.01	46.07	0.02	46.09	0.13	0.03
5,966,329.814	598,179.544	47.25	0.04	47.29	0.01	47.30	-0.05	47.25	0.10	47.35	0.05	47.40	-0.01	47.38	0.13	0.02
5,965,877.874	598,104.519	47.79	0.03	47.82	0.02	47.84	-0.05	47.79	0.13	47.92	0.08	47.99	-0.04	47.95	0.16	0.03
5,965,780.005	599,412.980	50.32	0.05	50.37		-	-0.07	50.30	0.24	50.54	-0.01	50.52	-0.01	50.51	0.19	0.04
5,965,164.172	598,941.983	48.03	0.01	48.04	0.01	48.05	-0.03	48.03	0.10	48.12	0.04	48.16	0.01	48.18	0.14	0.02
5,965,144.554	599,903.228	49.09	0.02	49.11		-	-0.01	49.10	0.14	49.24	0.00	49.24	0.01	49.25	0.16	0.03
		Initial Survey FB: M18-03, PP. 5-6. Date: Oct 19-20, 2018 Input: JJ 11/8/18 Che: KMD 11/10/18		Study #2 Survey FB: MI38-03, PP. 7-12. Date: Nov 16-18, 2018 Input: JJ 11/20/18 Chr. CS 11/21/18		Study#3Survey FB: Mi18-03, PP. 13-14. Date: May 14-15, 2019 Input: KMD 5/15/19 Chk: JJ 5/28/19		Study #4 Survey FB: MI38-03 Pp. 15-17. Date: June 15-17, 2019 Input: KMD 6/17/19 Chr. TFB 6/18/19		Study #5 Survey FB: MI18-03 PP. 19-20. Dates: Nov 21-22, 2019 Input: KMD 12/11/19 Chk: JJ 12/11/19		Study #6 Survey FB: MI18-03 Pp. 22-24. Dates: Dec 16-18, 2019 Input: KMD 12/21/19 Chc TFB 12/27/19		Study #7 Survey FB: MI20-01 PP. 05-06. Dates: Jan 14-15, 20:20 Input: KMD 1/19/20 Chic xxx x/x/x		

